Manure-DNDC: Modeling impacts of management alternatives on NH_3 and GHG emissions from animal farms

(A on-going project supported by California Energy Commission PIER programs and USDA NRI)

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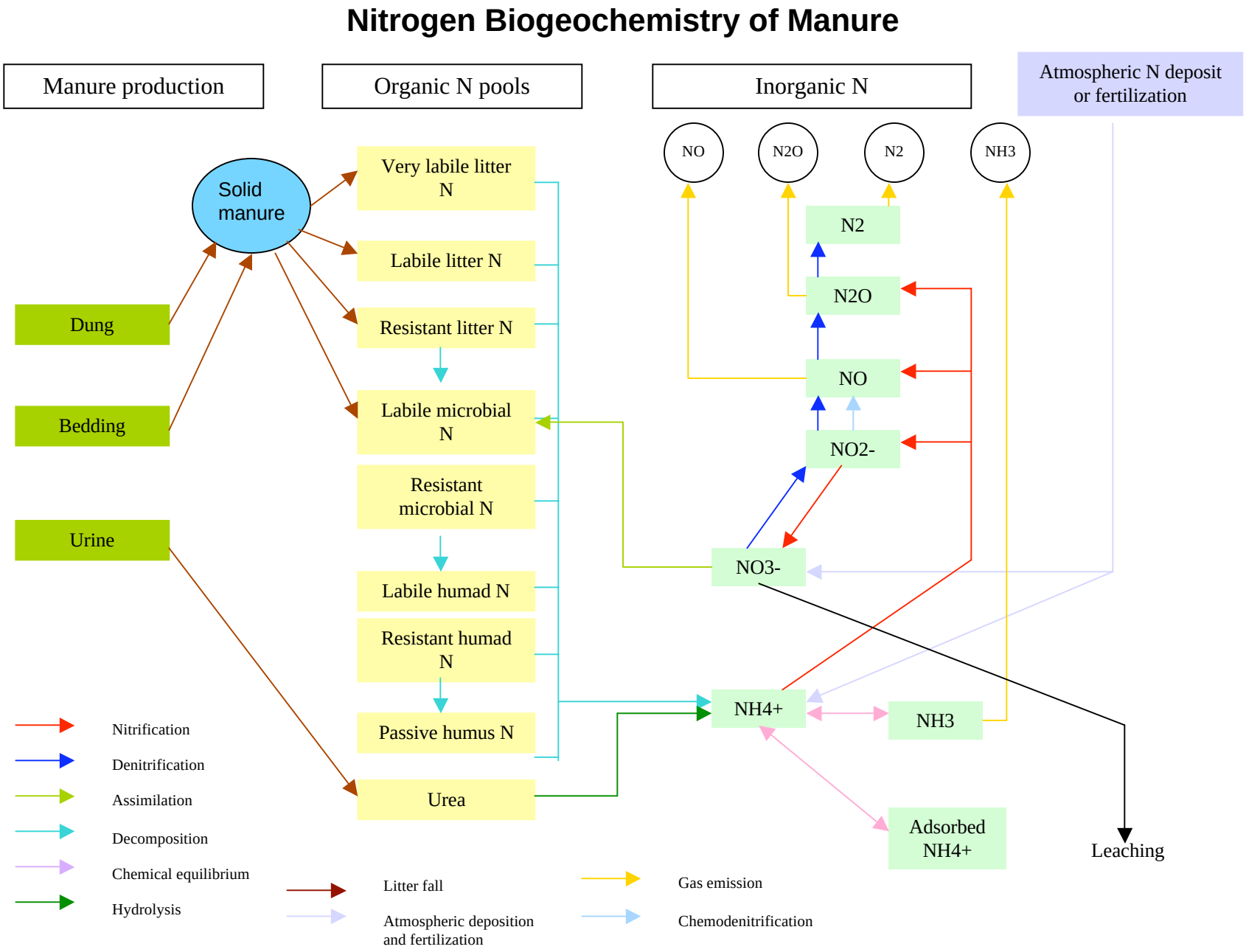
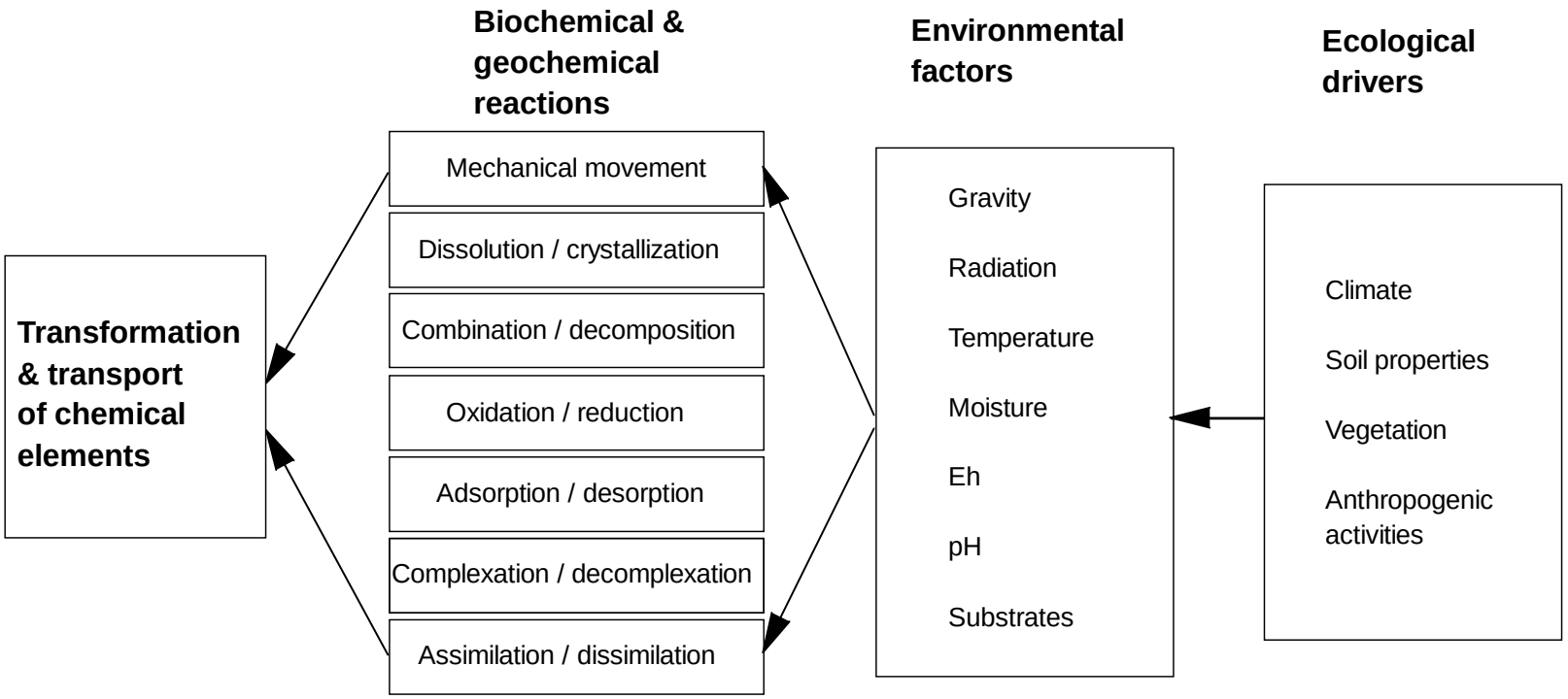
Goals:

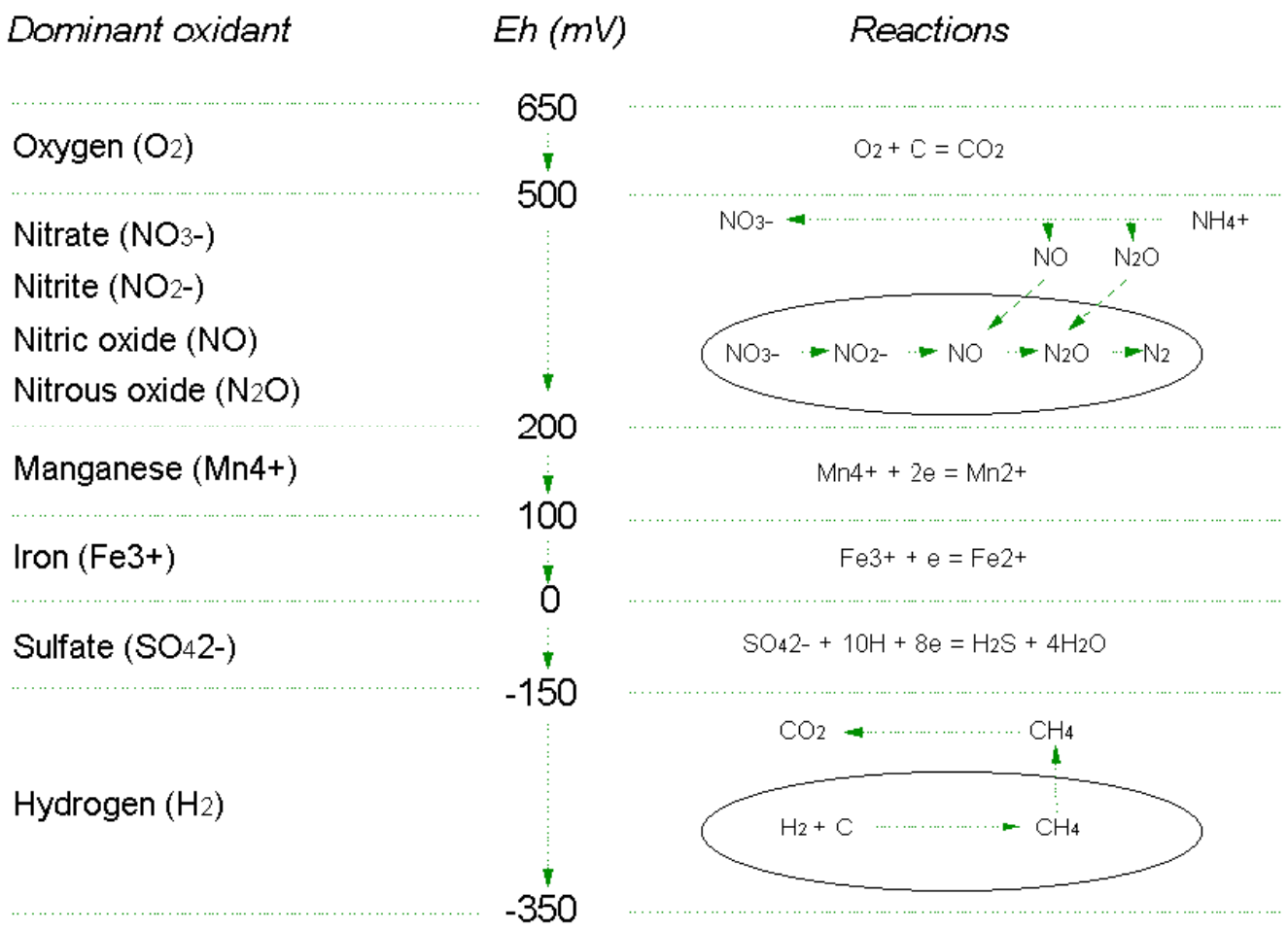
1. Develop a process-based model to quantify trace gas emissions from manure life cycle;
2. Assess management alternatives for mitigation of NH_3 and net GHG emissions from animal farms.


Nitrogen Biogeochemistry of Manure
Manure production
Organic N pools
Inorganic N
Atmospheric N deposit or fertilization
Solid manure
Dung
Bedding
Urine
Very labile litter N
Labile litter N
Resistant litter N
Labile microbial N
Resistant microbial N
Labile humad N
Resistant humad N
Passive humus N
Urea
NO
N2O
N2
NH3
N2
N2O
NO
NO2-
NO3-
NH4+
NH3
Adsorbed NH4+
Leaching
Nitrification
Denitrification
Assimilation
Decomposition
Chemical equilibrium
Hydrolysis
Litter fall
Atmospheric deposition and fertilization
Gas emission
Chemodenitrification

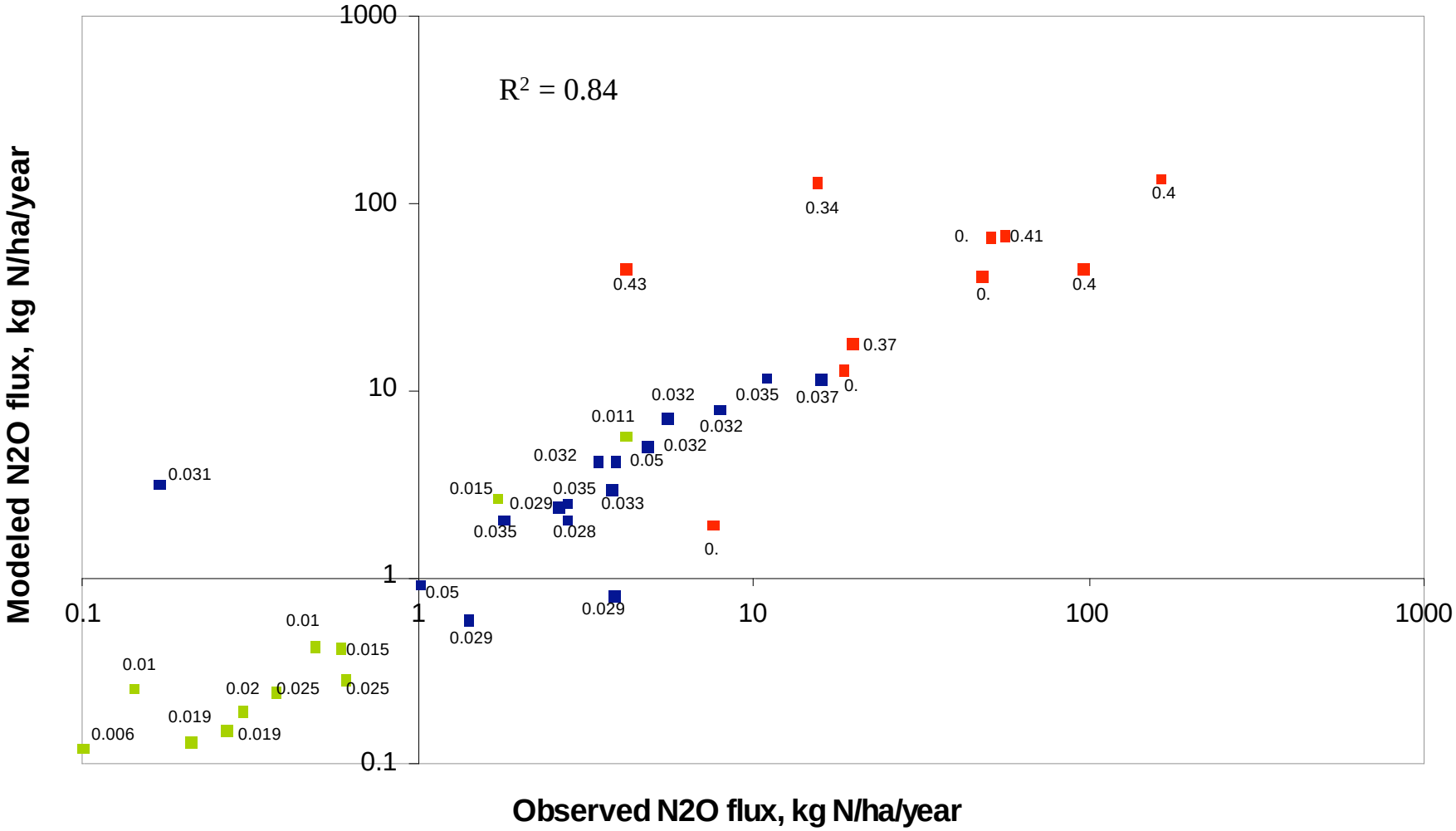
Biogeochemical processes controlling C and N transformation in soil organic matter have been developed in DNDC



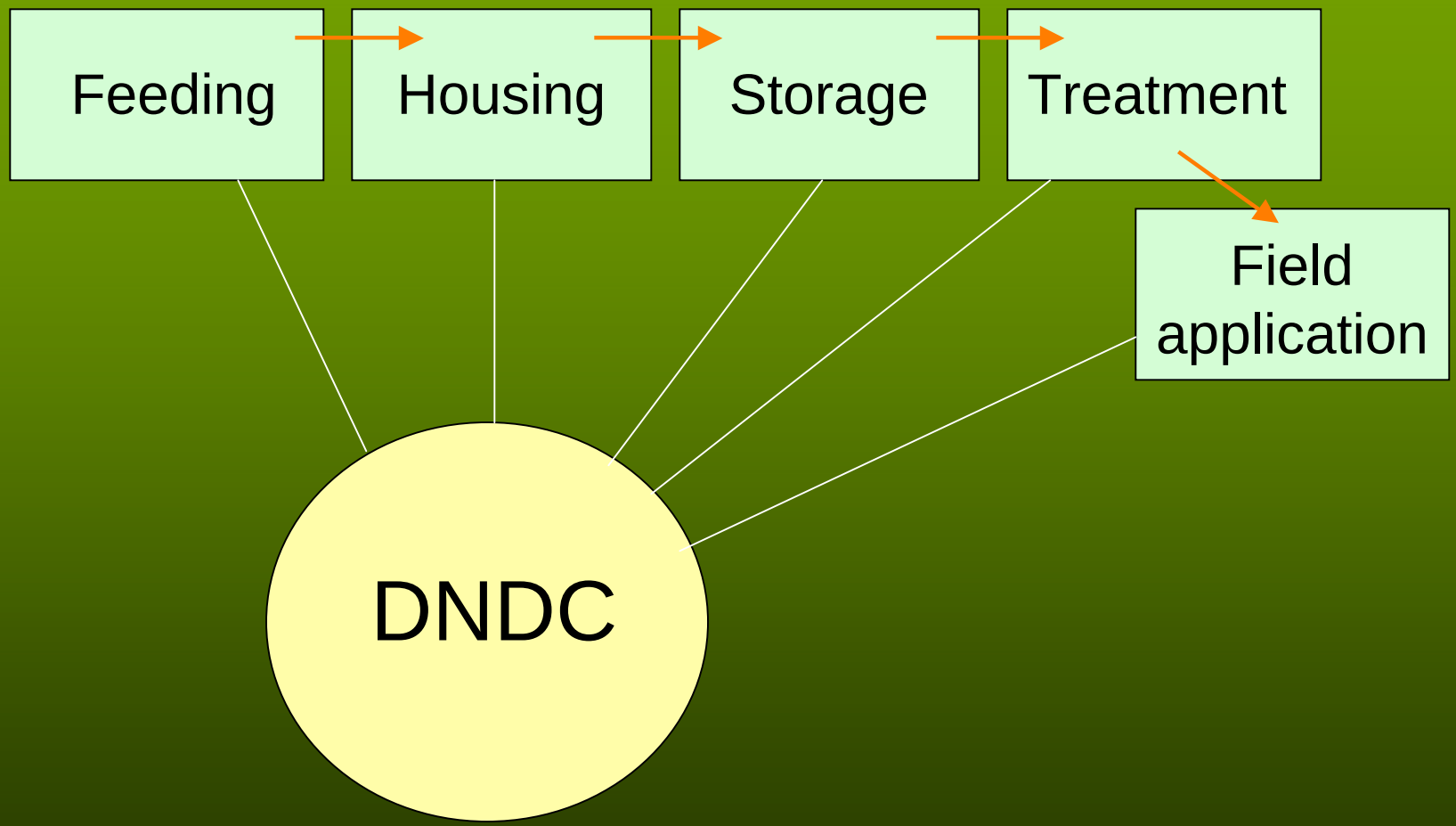
DNDC quantifies trace gas emissions by tracking microbial activity in soil organic matter



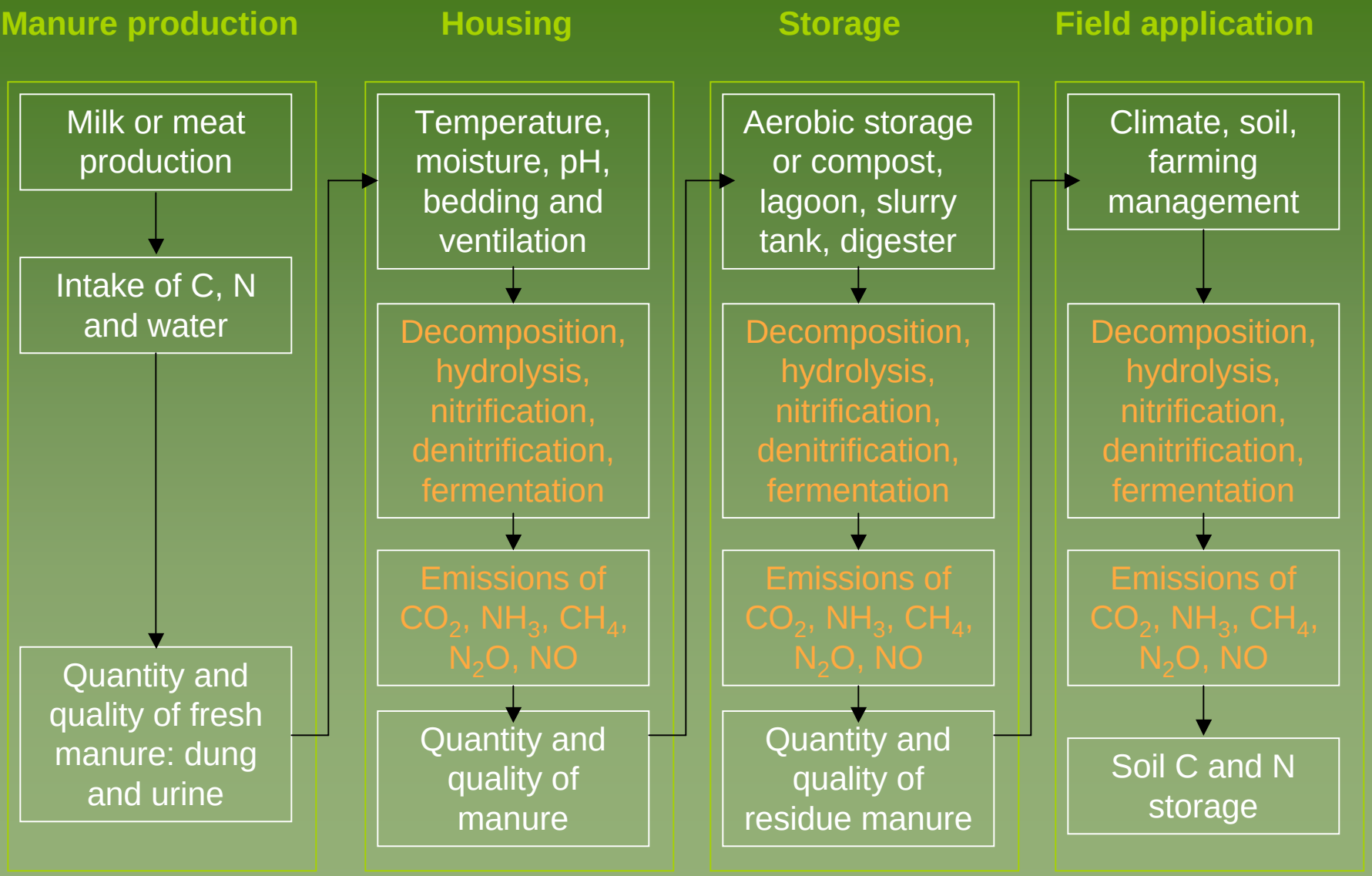
DNDC has been tested against a wide range of datasets of CO2, CH4, N2O, NO and NH3 emissions observed worldwide



Create Manure-DNDC by linking farm components to DNDC



Manure-DNDC utilizes the existing biogeochemical processes to track manure turnover in the farm components



Input parameters:

- Daily climate data;
- Animal type and population; milk/meat production; Intake protein and feed quality;
- House ventilation; floor surface and bedding; cleaning method;
- Compost size, density, storage time, litter addition;
- Lagoon capacity, surface area, coverage, draining frequency;
- Slurry tank capacity, coverage, storage time;
- Anaerobic digester capacity, CH4 production;
- Manure field application: amount, C/N, timing, depth.

Output parameters:

- Production of urine and dung;
- Enteric CH_4, N_2O and CO_2;
- Emissions of CH_4, N_2O, NH_3, NO, N_2 and CO_2 from feeding lot, compost, lagoon, slurry tank and field;
- N leaching and uptake in field;
- Crop growth and yield;
- Soil C sequestration.

Manure-DNDC is being calibrated with datasets observed in house, storage and field …

Measurements are conducted at feed-lot, housing, storage, lagoon and field in dairy farms in UC-Davis, Merced, Tulare, Stanislaus and Kings, CA in 2005-2007.

Tests of Manure-DNDC for a typical dairy farm in California:

-Located in the Central Valley;

-500 cows with milk production 10 kg/head and weight gain 0.8 kg/head per day;

-Feeding rate 6.8 kg DM with protein 0.43 kg/head per day;

-Dung and urine separated for compost and lagoon, respectively;

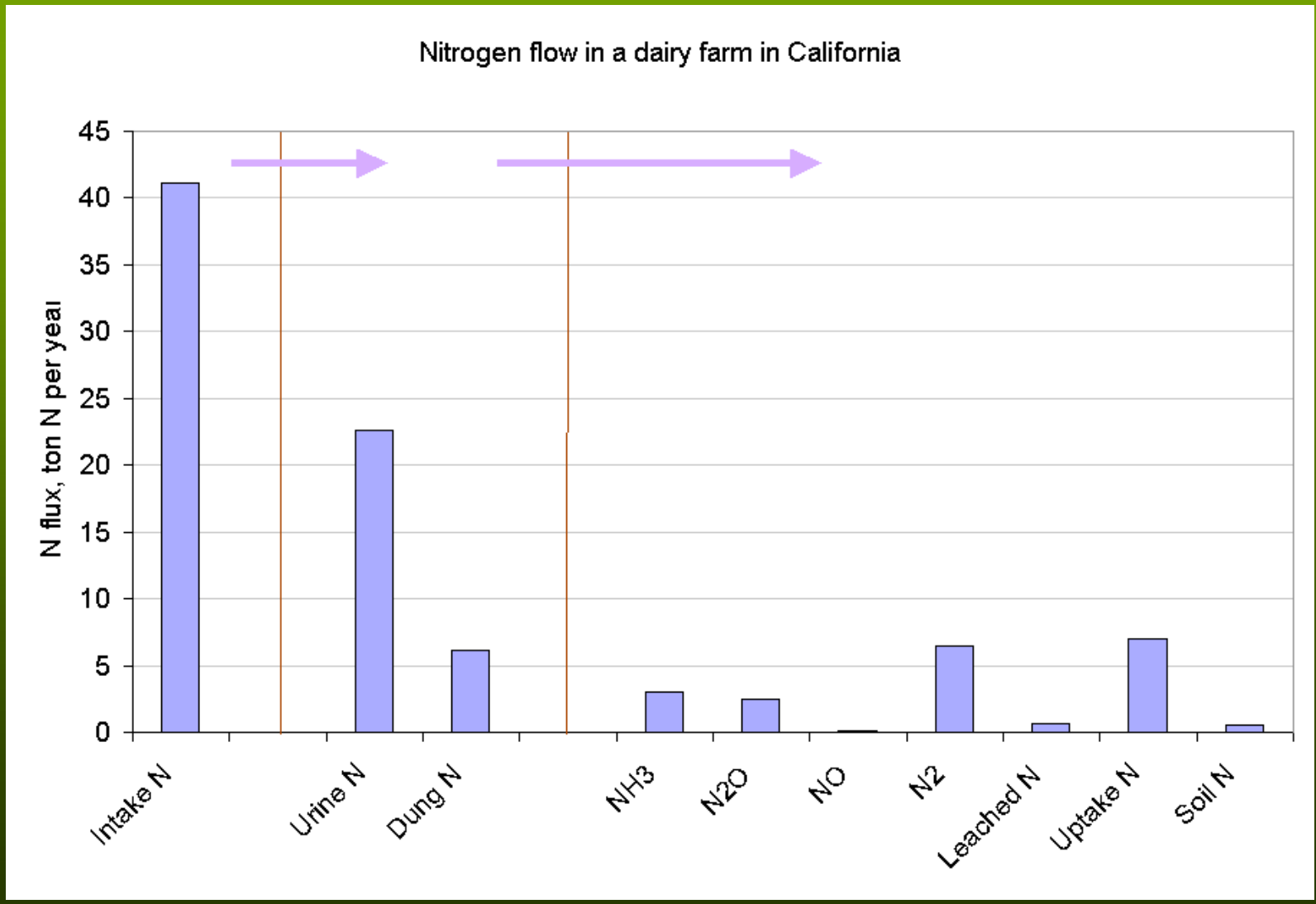
-Compost litter addition 2000 kg DM, C/N ratio 45;

-Lagoon capacity 2000 cubic meter, surface area 200 m^2;

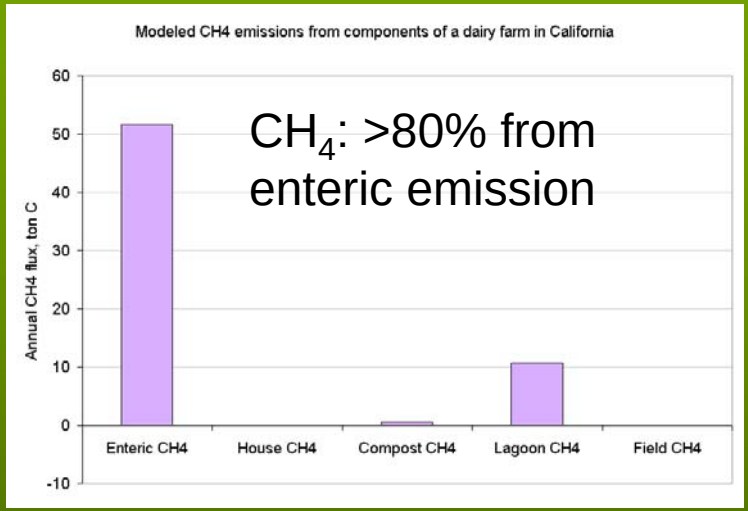
-No slurry tank or anaerobic digester utilized;

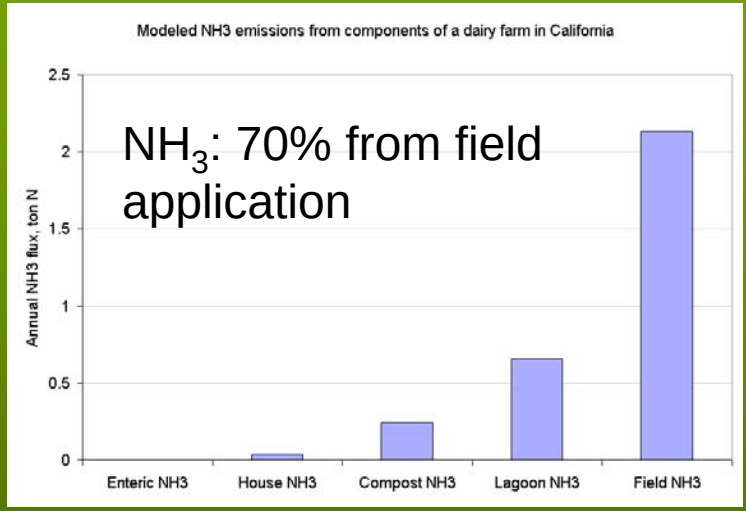
-Lagoon manure application depth 20 cm.

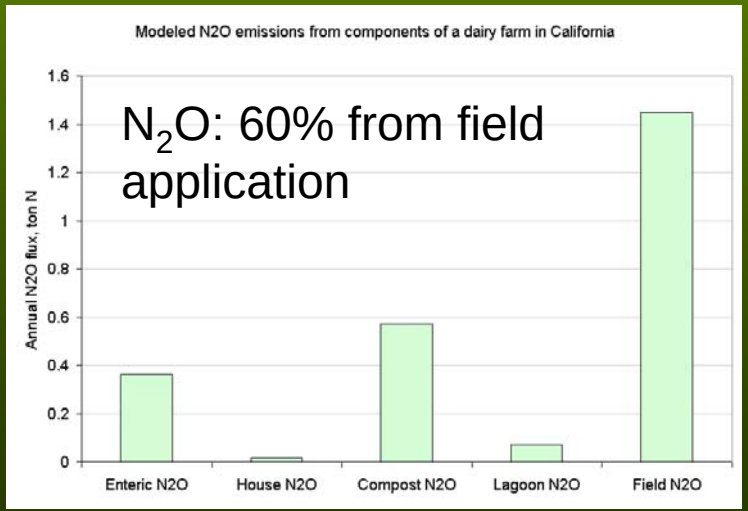
Manure-DNDC tracks N transport and transformation at farm scale

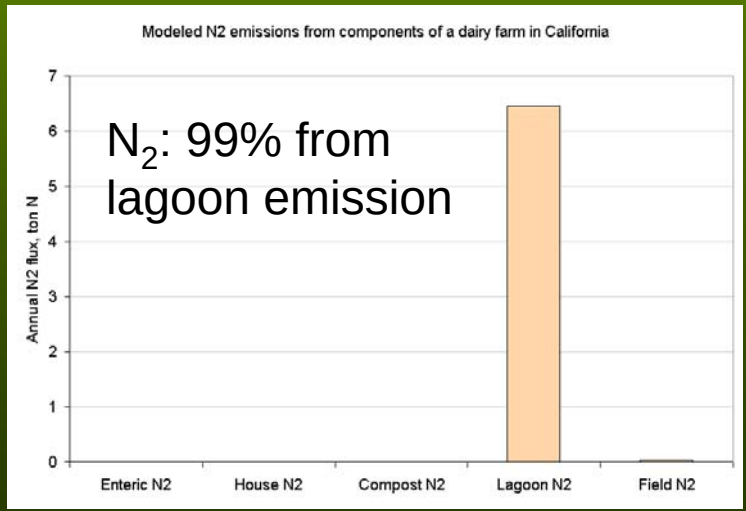


Emissions of CH_4, NH_3, N_2O and N_2 are dominated by different farm components

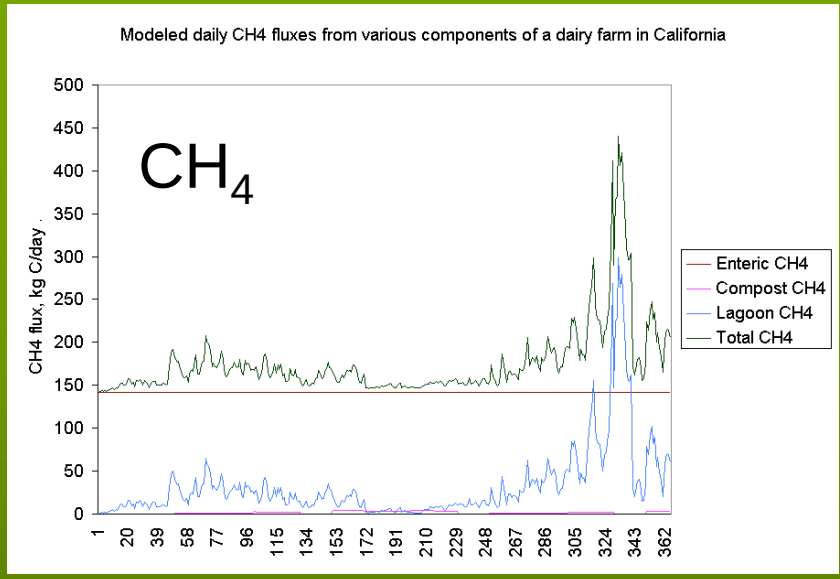


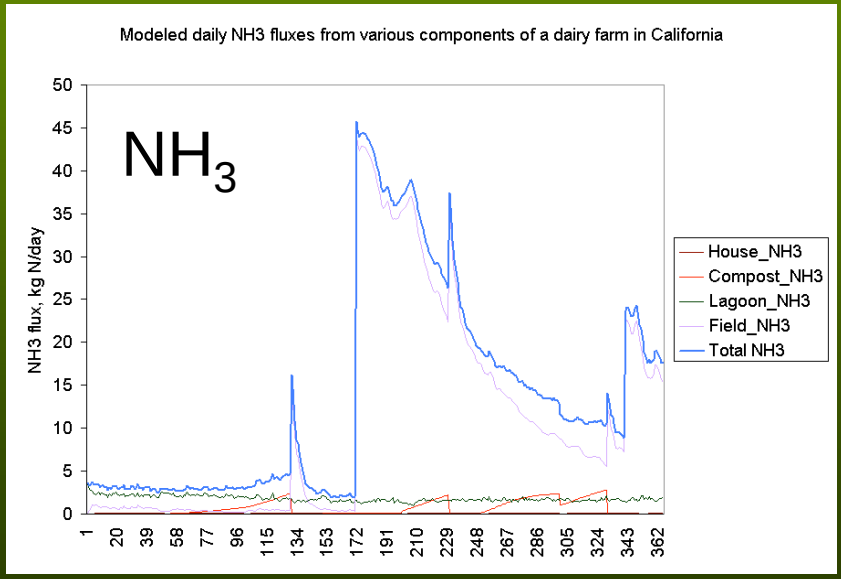


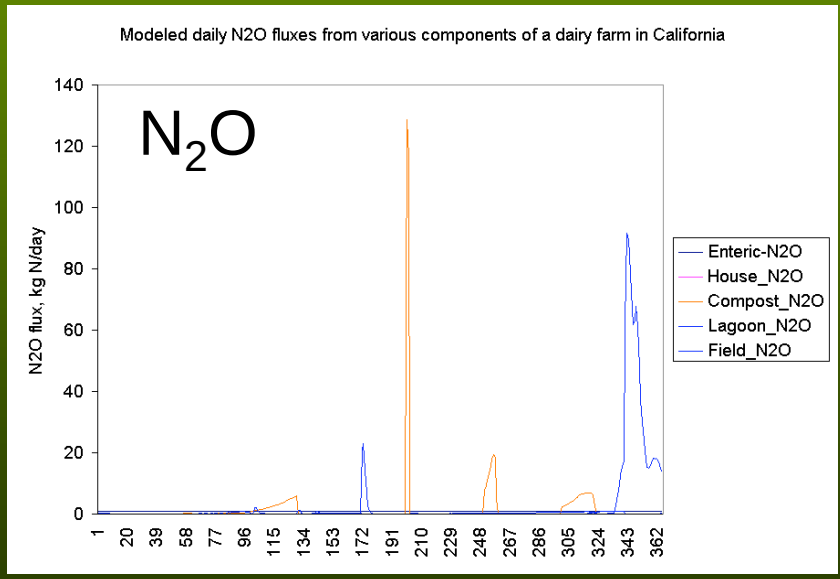




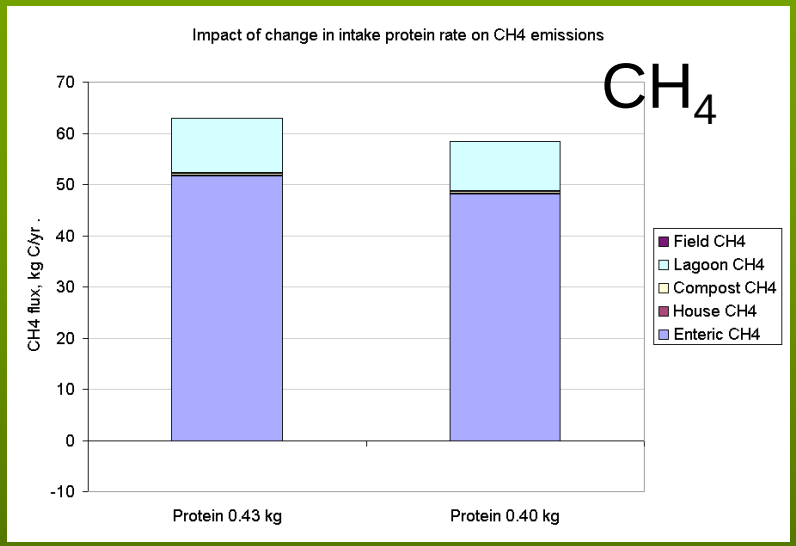
Modeled daily CH_4, NH_3 and N_2O emissions from a dairy farm in California

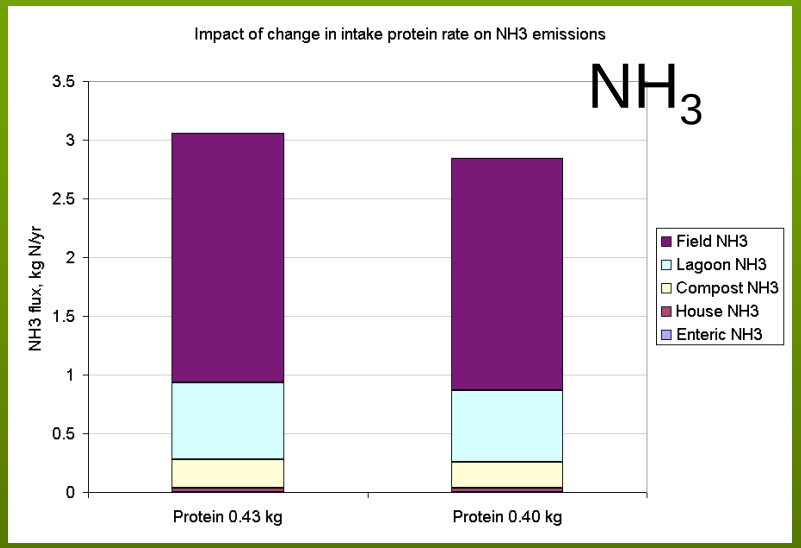


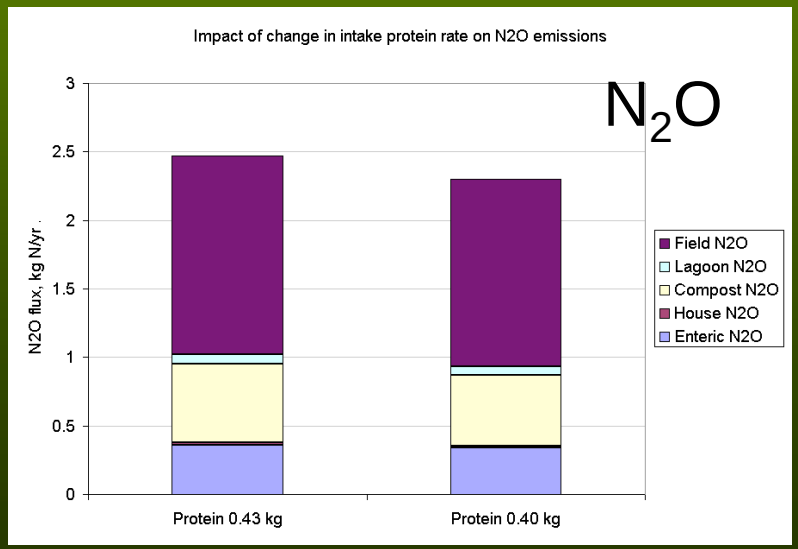


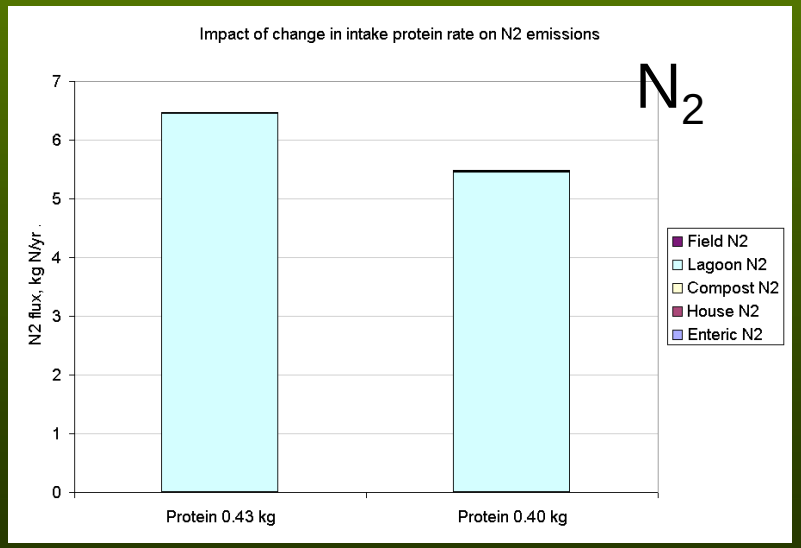


Impact of change in intake protein rate on gas emissions

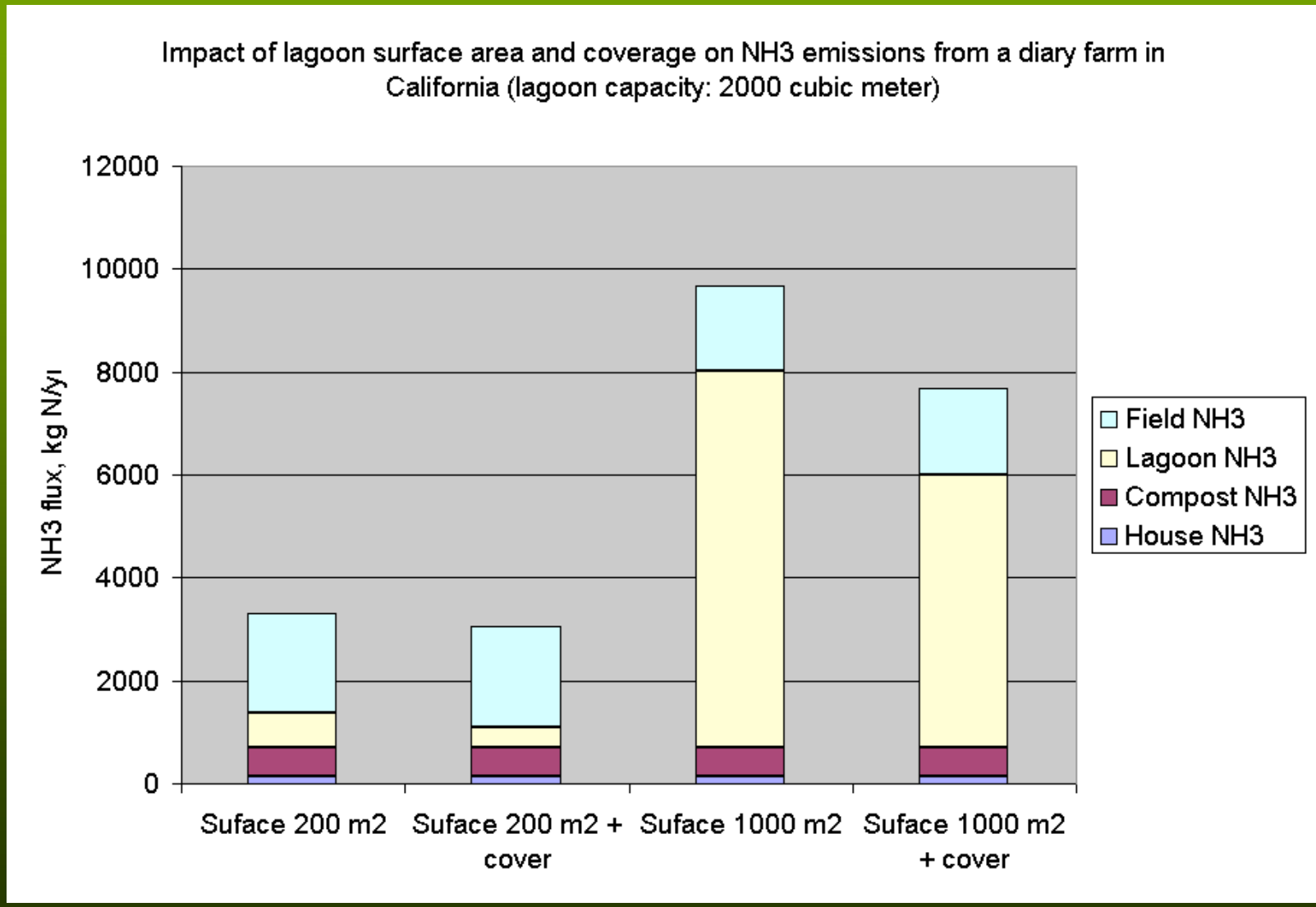




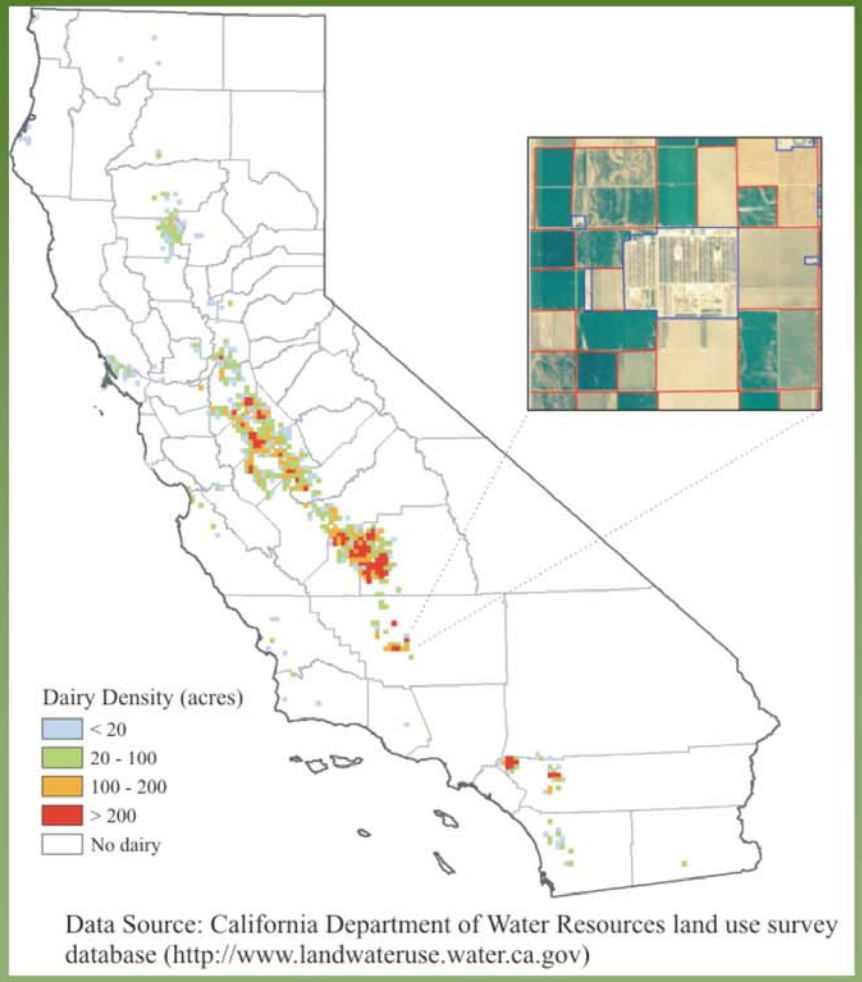




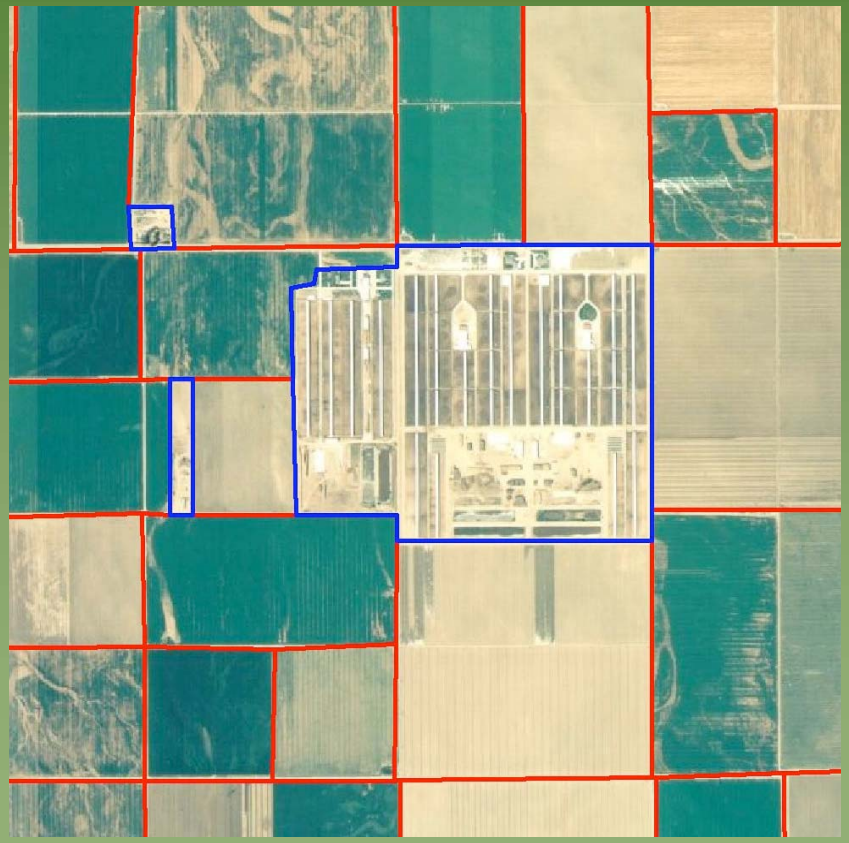
Impact of lagoon surface area and coverage on NH_3 emissions



GIS database will be constructed to support regional simulations for CA dairies



Climate, soil, livestock and management information will be collected for each farm



Expected Project Outcomes:

- A modeling tool for estimating air emissions (CH_4, NH_3, N_2O, NO) and N leaching from California dairies;
- GIS databases on dairies (location, types, herd sizes, manure management, local soils, climate, etc);
- Regional estimates of NH_3 and GHG emissions from California dairies;
- Assessment of mitigation strategies for reducing NH_3 and GHG emissions from dairy farms in California.

Acknowledgements:

We thank the California Energy Commission PIER Programs and USDA NRI for their supports to this study.